

Dynamic Optimization of Phenomena Mapping

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Abstract: Nowadays, urban phenomena such as air quality, noise or heat wave are becoming global issues. There are more and more researches on these phenomena, almost of them are still complex to estimate and to map. In most cases, phenomenon mapping is difficult for non-expert people to understand because two reasons. The first one is the phenomenon is not contextualized or overlaps its context, therefore people cannot locate this phenomenon to understand it in the context neither estimate its impact. The second reason that makes map perception difficult is that the data density is not adapted for visualization. Sometimes the data is too dense thus it overlaps itself or its context, else the data is too sparse to follow the variation of the phenomenon. For facility of map interpretation, we want to propose methods to improve visual perception by visualizing a phenomenon with its context and at different levels of detail (LoD) and by adjusting data according to view condition (zoom level, context and observer's position). To do that, we propose a conceptual data model for effective database organization and an optimization process of three steps.

Keywords: Visualization, Level of Detail, Dynamic mapping, 3D mapping, multi-resolution data, multi-scale representation, phenomena mapping, adaptive mapping

1. Conceptual data model to facilitate phenomena mapping

In the data model we represent a phenomenon as a series of episodes. Each episode describes the phenomenon in an area and during a certain time. An episode is then characterized by a set of value field. Each value field is symbolized by a default geometric structure, called initial grid composed of nodes.

To visualize the phenomenon at different LoDs, we distinguish raw data from data for mapping by proposing a multi-scale data structure for cartographic objects (Frank et al. 1994) (Zhou et al. 2004) (Ruas 2015). In the data structure, we introduce **value fields for mapping (VFM)**. Each VFM represents the phenomenon at one time and at one LoD, it is computed from initial value field by interpolation or generalization. A VFM is defined in an interval of scale. VFM is carried on an *adapted geometric structure*, can be an adapted grid composed of nodes or a plan composed of cells.

To view the phenomenon at different LoDs, we create a VFM for each possible LoD. But if we create too many tables in the databases, it becomes time consuming. Reversely, building one or two LoD(s) is fast but the visualization may be rough. Thus, we propose to add a temporary data called **dynamic adapted value field (DAVF)**. Whenever one of the parameters of views changes the DAVF and its *adapted geometric structure* are readjusted.

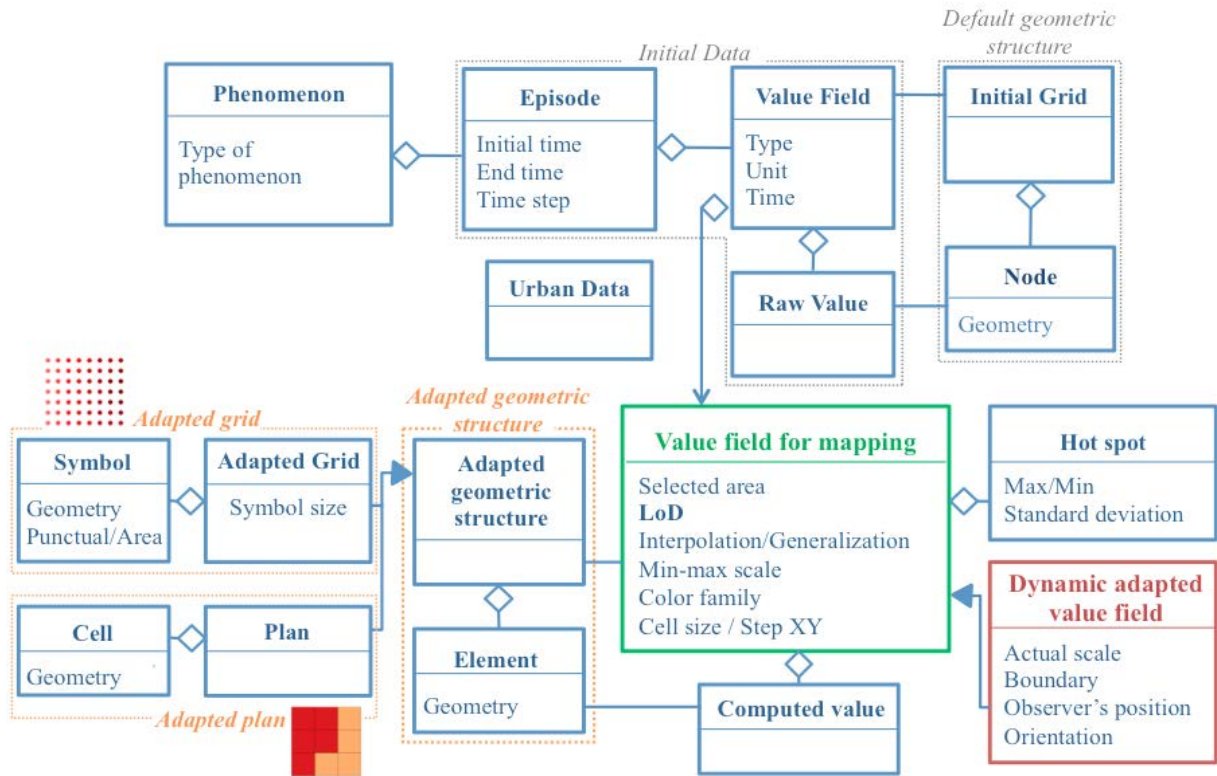


Fig. 1. Conceptual data model to facilitate the phenomena mapping at multi-scale

2. Process to optimize phenomena mapping in 3 steps

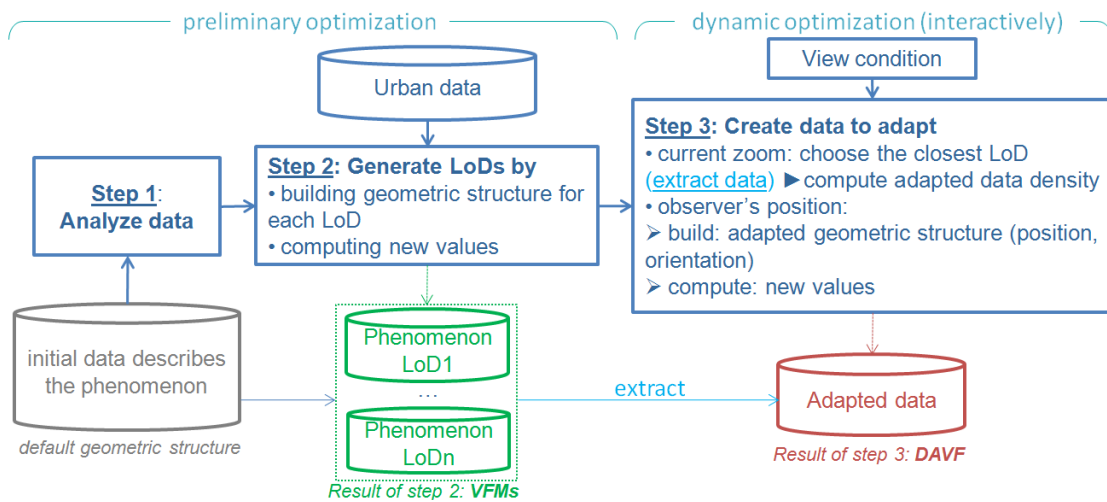


Fig. 2. Process of dynamic optimization in three steps

First step: Data analyze

From initial data and requirements, we decide 1- *how many LoDs we should create* and 2- *each LoD used from which scale to which scale (min-max scale)*.

We also propose that each LoD is defined by an object called geographic reference object. This object helps us to estimate the size of a grid or a plan corresponding to the LoD: it can be the outlines of a city, a district, buildings, or a street. For example, if people want to study the influence of building effects on local temperature, the street becomes a geographic reference object of the LoD. Then the medium street width is taken as a reference value in order to define the grid threshold.

On one side, an adapted grid allows users to visualize the phenomenon with its context because nodes with reasonable distance do not hide surrounding information. On the other side, a plan allows to see and follow the phenomenon's variation due to its continuous. Almost phenomena demand a multi-scale representation to understand them at global and local level, thus we suggest using **plan for LoD1** (the smallest scales) and **grids from LoD2 to LoDM** (the biggest scales).

Second step: Create data for each LoD

For each LoD, we create one value field for mapping (VFM) by building an adapted geometric structure (adapted grid or plan) and computing values from the initial one.

A *value field for mapping* is stored in database with its parameters like the table below:

- *Selected area*
- *LoD*: the level of detail that the VFM corresponds
- *Interpolation/Generalization*: The method used for computing new values.
- *Min-max scale*: an interval of scale where the VFM adapts the visualization.
- *Color family*: the colors used to symbolize the phenomenon and classification of values.
- *Cell size / Step XY*: the smallest geographic unit that we want to observe the phenomenon.

After this step, we have more data: the value fields for mapping. Each of them corresponds to the phenomenon in one time and at one LoD.

Thirst step: Dynamic data to adapt for view conditions

To adjust the data each time to view condition changes, we create a dynamic adapted value field (DAVF). A DAVF is computed from a VFM and is a type of VFM (in heritage and derivation).

When one of parameters of view changes, the DAVF is updated to adapt for new condition:

- **Actual scale**

Firstly, we compare the actual scale with the parameter of min-max scale of each VFM stored in database. We choose the VFM with the scale interval that encloses the actual scale. Then we extract data from this VFM to prepare the adaptation.

In almost cases, we symbolize a phenomenon with area symbols because they support well to zoom and do not cause the overlap between themselves at small scale as punctual symbols do. However if scale decreases too much the area symbols become too small to see. In these cases, we use punctual or linear symbol for small scale and area symbol for large scale (Ruas *et al.* 2015). Now we have another problem to solve: the visualization may be rough between two LoDs. Moreover, as we said above if we store too many tables in the database, the step 2 becomes time consuming. *Thus we propose to make the data density vary between two stored LoDs*. Each time scale changes, we readjust data density.

– **Orientation inside a Boundary**

There are two modes of optimization: global (for maps in 2D) and local (for 3D). By default, the optimization is global (2D), it means we adapt phenomenon data for all objects inside the limit of canvas called boundary. We compute a good grid orientation.

By default the grid orientation is defined by the angle between the axis of the grid and the abscissa. To reduce the overlap between phenomenon data with the context, we propose to compute a value of orientation that minimizes the obscure rate of the grid in the boundary.

– **Observer's position and orientation**

If we choose to view the phenomenon in mode “observer”, the adaptation should be local. It means that we modify the data in order to facilitate only the observation of data surrounding the observer. To do that, we locate the street where the observer see the phenomenon then compute its orientation. Finally, we orient the grid according to this street in order to maximize the number of visible nodes.

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